

Cultural Geography Modeling and Analysis in Helmand Province

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ABSTRACT

This paper provides an overview of the application of an agent-based model called “Cultural Geography” to represent the civilian populace. This project uses a multi-agent system consisting of an environment, agents, objects (things), operations that can be performed by the agents and laws governing operations in the environment. The environment for this particular application consists of six districts within Helmand Province, Afghanistan.

Covered in this document is the study plan development to define the scope, objectives, and analytic approach of the project. Data development techniques to find the relevant information pertaining to the socio-demographic dimensions of the populace, influencing groups, and services available are defined. Particular attention will be given to the population data that includes narrative identity, values, beliefs, interests, and social networks of the various groups. Social theories resident in the model will be addressed, as well as their instantiation within the scenarios. Finally, analysis results from the fractional factoria design of experiment will be presented.

1.0 BACKGROUND

This paper reports on the approach, findings and recommendations of the Cultural Modeling Support to the Pakistan-Afghanistan (PAKAF) Strategic Multi-layered Assessment (SMA). The U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) in Monterey, California and the Program for Cultural and Conflict Studies (PCCS) at the Naval Postgraduate School (NPS) led this cultural modeling effort for six districts in Helmand Province, Afghanistan. Team members consisted of Agent-Based Model (ABM) experts, computational social scientists, data development experts, and Afghanistan scholars. The study team also engaged Afghanistan Subject Matter Experts (SMEs) from the University of Nebraska – Omaha and Georgia Technical Institute to elicit their expert opinion and assess products.

1.1 Objectives and Benefits

The study objective was to determine the impact of operations on the populace over time for three specific issues. The three issues considered for this work included security, infrastructure, and governance. The results are to inform decision-makers of possible Courses of Action (COAs) and effects in Helmand Province to support Counterinsurgency (COIN) and stability operations. These effects are measured along the lines of operations and measure the population’s issue stance on:

- Security. Securing the population is a critical tenet for COIN and stability operations. The Taliban poses the greatest threat to security in the form of terrorizing the population, planting Improvised Explosive Devices (IEDs), and deliberate attacks against Afghanistan National Security Forces (ANSF) and International Security Assistance Force (ISAF). Security is defined as whether the population perceives security to be adequate (or inadequate) in Helmand.

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- Infrastructure. Essential services and the supporting infrastructure for essential services is a critical function of government and society. This issue relates to infrastructure and essential services and concerns whether the population is satisfied with the current state of infrastructure and near term prospects, or whether the population believes the current state of infrastructure and the processes for improving infrastructure are unsatisfactory. Infrastructure is defined as whether the population perceives infrastructure to be adequate (or inadequate) in Helmand.
- Governance. The third issue relates to governance and whether government structures provide fundamental government services, such as policing forces and legal processes. Governance is defined as whether the population perceives existing government structures and services to be adequate (or inadequate) in Helmand.

Benefits from the study include:

- Population data in terms of influential groups, narrative identities, beliefs, social network ties, and population distributions across Helmand districts,
- SME survey data regarding impact of events on population beliefs, and
- COA analysis that supports COIN and stability operations in Helmand Province.

1.2 Limitations and Assumptions

1.2.1 Limitations

The following limitations were imposed on the study team due to specific time constraints and our own ability to model only a portion of the entire conflict ecosystem. First, the study team refined the area of interest to six districts in Helmand Province where we could focus our data development effort with the Afghanistan scholars on the team. These districts consisted of Kajaki, Sangin, Gereshk, Lashkar Gah, Nawa-i-Barakzai, and Garmsir. Of all possible events that could happen in these districts, only 14 specific events were modeled based on the most relevant events as described by the SMEs. The frequencies of these events remained constant throughout the simulation, i.e. there was no dynamic manipulation of the event cycle based on the response of the population. Representing the population of roughly 600,000 Afghans were 200 agents. Finally, the temporal nature of population interests, which effect issue stances, requires frequent re-calibration. Population groups in Helmand Province often shift allegiances and align with various organizations to meet basic needs, to include security and sustenance. Given the temporal nature of the data, the study team deemed model results appropriate out to six months. Executing the model beyond six months requires data re-calibration and review by SMEs to adjust to varying security, infrastructure, and governance conditions.

1.2.2 Assumptions

The following are assumptions that the study team made. If these assumptions are proven false, then the integrity of the analysis is in jeopardy. First, the team relied on fully vetted SME input, with multiple years of experience concerning Helmand that we feel adequately represented the impact of events on the population identity groups. We determined that fifty-two stereotypes encompass the major population identities within Helmand Province that provide sufficient insight on the changes in the population issue stances for the scenarios. Finally, we used six months as the limit to the validity of the projection into the future without recalibrating the impact of events.

1.3 Organization of the Presentation

This presentation is organized into five sections. This first section provides the background for the research, specified objectives, limitations, and assumptions. The second section contains a description of

the Cultural Geography (CG) model. The third section contains the detailed process and methodology that the study team followed. Finally, sections four and five provide the results of analysis and a summary, respectively.

2.0 CULTURAL GEOGRAPHY (CG) MODEL

The study team utilized the CG model developed by TRAC-Monterey for the Helmand study. The CG model is an ABM of the operational environment based on doctrine and social theory designed to address the behavioral response of civilian populations in conflict environments[1]. The model is patterned after the conflict eco-system described by Kilcullen[2] in an attempt to capture the complexities of irregular warfare shown in Figure 1.

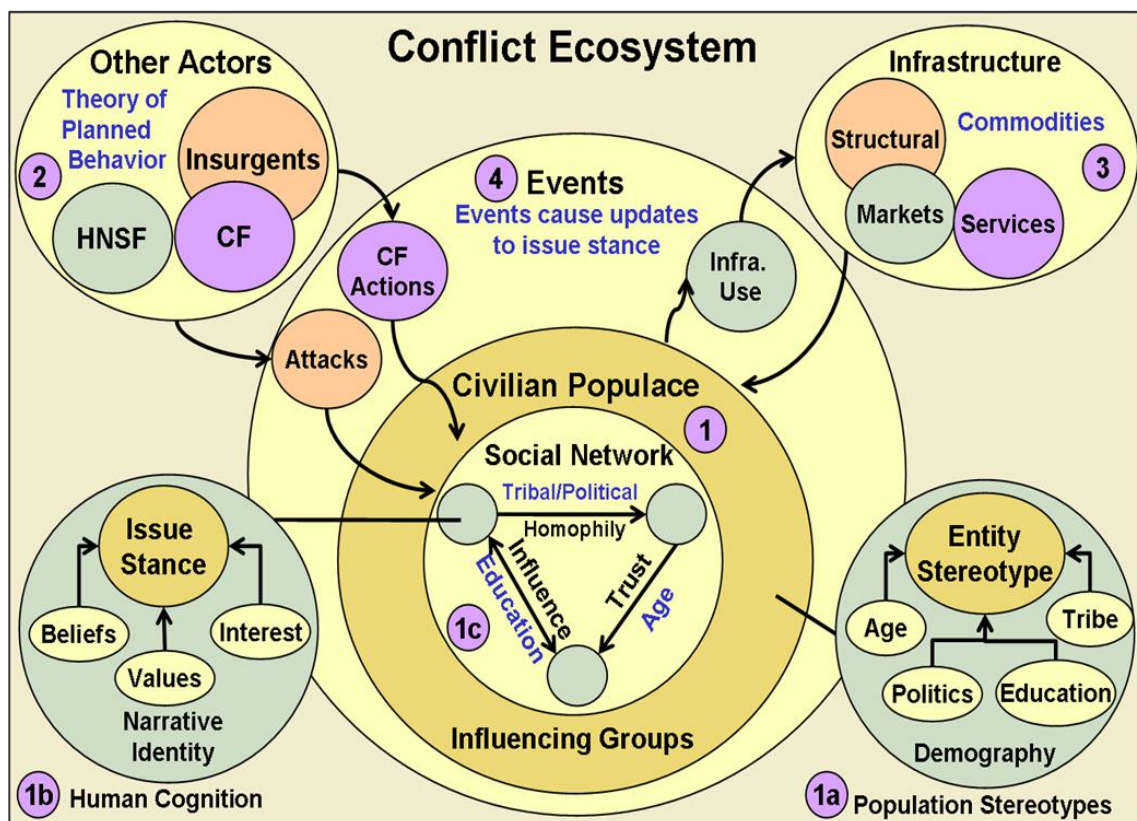


Figure 1: The Cultural Geography (CG) Model.

The CG model consists of entities (people) interacting with each other and responding to specific events. Each entity is defined by a set of demographic dimensions that collectively shape the entity's beliefs, values, interests, stances on issues, and behaviors. The narrative paradigm is the underlying social theory upon which narrative identities are developed to form entity beliefs, values, and interests.

The CG model enables the user to schedule events that impact population beliefs and stances on critical issues through implementation of Bayesian networks for issues. Parent nodes of the issue networks are the beliefs and interests of target population groups derived from their narrative identities. The end nodes of the issue networks are the entity's issue stance. An example of a scheduled event may be insurgents killing a community leader or a Non-Governmental Organization (NGO) providing medical care.

Population behaviors may also impact belief nodes, and thus end node issue stances. An example of population behaviors may be seeking and acquiring essential services. Population behaviors are modeled in CG through Bayesian networks using the Theory of Planned Behavior (TPB). The TPB accounts for an entity's perceived attitude, norm, and control regarding a specific behavior[3].

Belief nodes may also be impacted through communication channels in a social network. The CG model supports representation of a social network by applying concepts of propinquity (physical proximity) and homophily (tendency to associate with those of similar interests). Specifically, when an entity's belief nodes change position, the entity attempts to communicate the result to other entities within a pre-defined physical distance that possess similar interests. If communication is successful, the receiver's beliefs are impacted accordingly.

3.0 METHODOLOGY

3.1 Data Development

The study team researched multiple resources to collect data for input to the CG model. Sources included first-hand accounts from Human Terrain Teams (HTT) deployed in theater, Afghanistan SMEs, results from professionally administered surveys (Gallup TM), interviews with members of Provincial Reconstruction Teams (PRTs), and open source references from Department of Defense (DoD), government agencies, academia, and news organizations.

The study team also reviewed and applied frameworks to assess the status of Helmand Province, to include essential services using the sewage, water, electricity, academics, trash, medical, safety, and other considerations (SWEAT-MSO) framework[4,5]. Additionally, questions to SMEs were developed to understand civil considerations[6,7] pertaining to areas, structures, capabilities, organizations, people and events (ASCOPE).

The first step in analyzing the data included the identification of potential demographic dimensions from a variety of traceable data sources for the population residing in the six districts of interest. The study team identified five major demographic dimensions and 13 associated demographic groups as depicted in the table below. All entities in the CG model are composed of one demographic group from each demographic dimension. For instance, an entity composition may be 'poor', align with a 'marginalized' tribe, live in a 'rural' location, possess 'moderate' political views, and be of 'military age'. We refer to each distinct composition of dimensions as a stereotype.

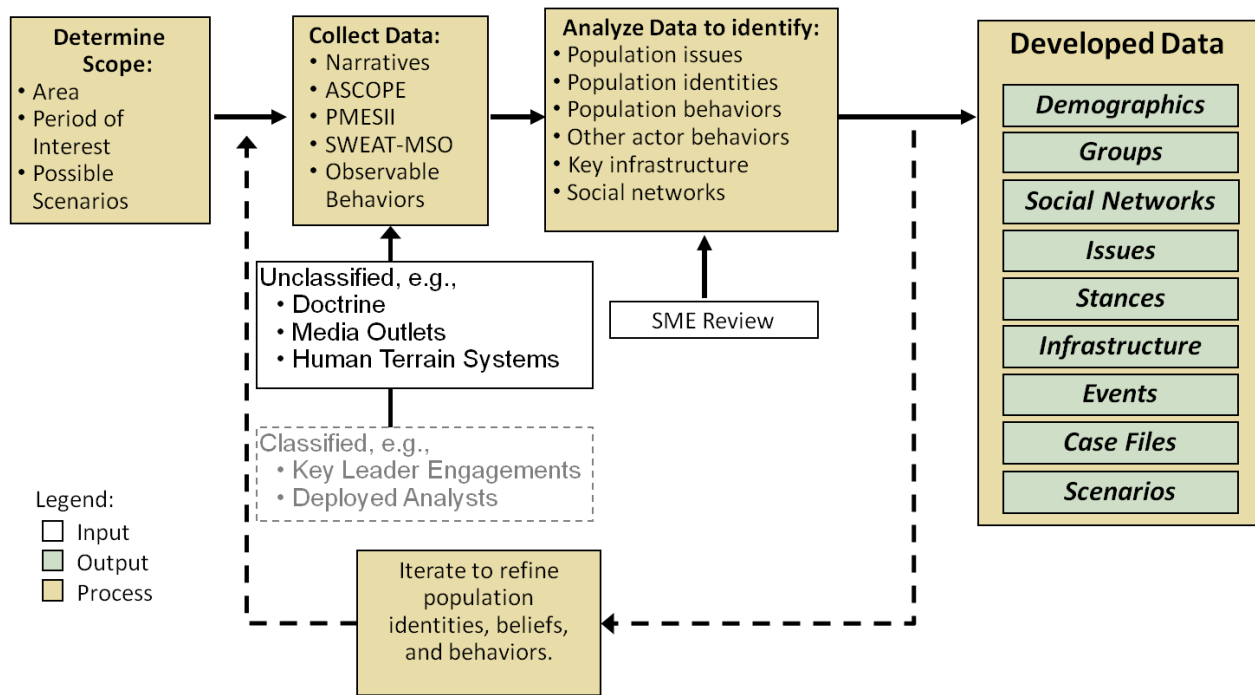


Figure 2: Data Development Methodology.

3.2 Population Groups

The study team broke down the population into the following groups which are listed in Table 1 and described below.

Table 1: Population Groups by Dimension.

Family Status	Tribe	Disposition	Political Affiliation	Age
Inherited ("Son of")	Pro-Government (Alizai)	Rural	Fundamentalists	Military Age Male
Achieved (Politics/Wealth)	Marginalized/Violent (Noorzai / Ishaqzai)	Urban	Moderates (Traditionalists)	Spin Giri ("White Beards"/Elders)
Poor/Unemployed	Passive (Barakzai/Alakozai)		Progressive/Secular	

3.2.1 Family Status

Although great variation exists between ethnic groups and groups practicing different modes of subsistence, families of virtually all Afghan groups are characterized by: patriarchal, patrilineal and patrilocal organization, low incidence of polygyny, even lower incidence of divorce, endogamous nature, and relatively high birth rate. Rigorously honored ideals emphasizing family cohesiveness through extended kinship networks endow the family with its primary function as a support system[8]. Given their distinct narrative identities, the study team modeled family status in terms of inherited, achieved, and poor/unemployed population groups.

3.2.1.1 Inherited

This status is defined by being the son of an elder whose family is regarded with respect (Khan, Malik, Spin giri (elders)) or religious titles such as Syyed or Maulawi (religious family). Inherited landed elite families and those businessmen who became rich through the poppy trade have had a significant rise to influence in Helmand, particularly in the drug market district of Sangin[9].

3.2.1.2 Achieved

This is status due to position of influence such as being a military commander or holding a formal position such as a member of parliament, Malik, Mirab, Mullah, Maulawi or any other government or factional post, or maintaining links to influential people at the district and provincial level. Achieved groups often attain wealth through business ventures that often include poppy farming (narcotics trade and their networks) and purchasing property (commercial and agriculture)[10].

3.2.1.3 Poor/Unemployed

Polling results estimate that 40% of the country's 25 million people are jobless and some five million Afghans live below the poverty line. Driving factors towards increasing instability, according to Afghans, are the high rate of unemployment and poverty in the war-wrecked country. Many of those fighters joining Taliban insurgents are illiterate tribal people, young seminarians, and low-educated jobless youths[11].

3.2.2 Tribe

Tribes in Afghanistan do not act as unified groups, as they have recently in Iraq. For the most part they are not hierarchical, meaning there is no “chief” with whom to negotiate (and from whom to expect results). They are notorious for changing the form of their social organization when they are pressured by internal dissension or external forces. We know, based on a large amount of recent and not-so-recent research that the meaning of “tribal society” in the Pashtun areas has changed a great deal even in the last hundred years. It is clear that there are many aspects of Pashtun life at least as important as “tribe,” if not more so[12]. However, unlike other Pashtun tribal areas of the country, the tribal structure in the southeast (e.g. Helmand Province) remains relatively more intact. Within the tribal structure today, *Pashtunwali* (the traditional customary law), common to all Pashtuns, is better preserved than in other Pashtun-dominated parts of the country. Further, the tribes of the southeast region have a unique tribal mechanism of policing (*arbakai*) for defense from external aggression and natural resource protection. While the coherence and strength of the tribal structure has been eroded in many parts of the region, there is still sufficient coherence among tribes to allow them to play a significant role in peace-building[13]. Given their distinct narrative identities, the study team modeled the tribal dimension in terms of pro-government, marginalized/violent, and passive tribes.

3.2.2.1 Pro-Government

The Alizai are Helmand’s largest Pashtun group. After 2001, the Helmand governor, deputy governor, spokesman for the Governor, chief of staff, director of education, finance officer, and many district chiefs or district administrators were from the Alizai tribe. For the Alizais, the current situation in Helmand provides an opportunity to do things their way under a fusion of tribal and federal government (rather than tribal and Taliban) leadership[14].

3.2.2.2 Marginalized/Violent

Many Noorzai are deeply associated with the narcotics industry. Within the Afghan tribal system, the Noorzai tribe is the most pro-Taliban and is a group that often complains of being disenfranchised. The Ishaqzai are a very important tribal group in the power structures of Helmand and at large they have been

severely marginalized in the post-Taliban governments by various Jihadi commanders. After 2001, the Ishaqzai were not given any part in government hence they joined the war lords and Taliban rebels[15].

3.2.2.3 Passive

The Barakzai tribe is seen to have benefited disproportionately in power and patronage from the Karzai government. Generally, the Barakzais are considered to have more education, government positions, land ownership, tribal unity and businesses[16]. The Barakzais are relatively more peaceful but are viewed by other tribes with envy and distrust. At the moment, the Alikozai have a live-and-let-live policy with the Taliban. They allow the Taliban free passage through tribal areas, but forbid the Taliban from mounting any operations there[17].

3.2.3 Disposition

The vast majority of the land in Helmand Province supports agriculture with only a few pockets of traditional urban infrastructure. Rural to urban migration in search of employment opportunities and access to better services and infrastructure has been a trend in Afghanistan since the 1960s, but has been more common during the recent period of refugee return. Approximately 50% of these migrants moved to urban centers with their families, while the others left families behind and instead sent money back to their villages[18]. The study team modeled the disposition dimension by rural and urban population groups.

3.2.3.1 Rural

Approximately 94% of people in Helmand live in rural areas. Most occupations are agricultural and tied to poppy cultivation, to include poppy growing, transportation, and security. Minor crops include apricots, grapes, melon. Tending animals (sheep, goats or camels) is also a rural occupation. Over 100,000 people live in indigenously displaced person camps across Afghanistan and over 1.8 million nomadic animal herdsman (Kuchi) frequently travel back and forth across the porous Afghan-Pakistan border (Ministry of Rural Rehabilitation and Development, 2007). An estimated 70,000 people live in three indigenous displaced person camps across the six districts under study in Helmand Province[19]. Around 55,000 households (380,000 people) are reliant on opium poppy cultivation in Helmand, which represents more than a third of the province's total population. The rural populace is often stereotyped as backward, conservative, naive, but trustworthy by Afghan urbanites.

3.2.3.2 Urban

Approximately 6% of the people in Helmand live in urban areas[20]. The major population centers in Helmand include Lashkar Gah and Gereshk. Many of the urban population occupations revolve around the grand bazaars and support to the larger market places. There are many small business owners. City dwellers are considered corrupt and untrustworthy by people in rural areas.

3.2.4 Political Affiliation

Afghanistan has a fragmented multi-party system, requiring parties to form coalition alliances to achieve political gain. Democratic processes continue to evolve as the country attempts to create a viable political infrastructure and extend political freedoms to the people. The study team modeled political affiliation in terms of fundamentalist, moderate, and progressive/secular population groups.

3.2.4.1 Fundamentalists

This group generally believes in a strictly Islamic state and the literal implementation of Shari'ah (Islamic Law). They are often pro-Taliban. They generally believe all foreigners should leave Afghan soil

immediately. They strongly oppose the Karzai leadership and have opposed the previous Afghan government led by Tajik, Burhanuddin Rabbani[21]. They generally still believe women are chattel (property).

3.2.4.2 Moderates

This party believes in a strictly Islamic state – most believe in the implementation of Shari’ah (Islamic Law). They hold mixed positions on Karzai governance with their biggest grievances being nepotism (family) and corruption[22]. They often share many of the same religious beliefs as the Taliban, albeit not as extreme. They believe in change, but they want to do it on Islamic terms in an Islamic way. They hold mixed views on women’s rights.

3.2.4.3 Progressive/Secular

This group believes in secular governance - Islam is separate from the government. They oppose radical Islam and generally accept Karzai governance. Most believe in universal education for men and women and advocate women’s rights. They are often called Constitutionalists, New Democrats, Royalists or even Ethno-Nationalists and are generally pro-democracy[23]. Much of this group is well-educated and may have strong ties with Iran or India.

3.2.5 Age

The life expectancy for Afghan men is just over 44 years. Given that, the study team established a break point of 40 years to delineate military-aged males from the elder generation. The study team modeled the age dimension in terms of young and old males, namely military age males and senior males known as spin giri.

3.2.5.1 Military Age Male

There are approximately 4.5 million male Afghans within the traditional warrior age and another 7.5 million Afghan boys under the age of 15. Every year, over 500,000 Afghan youngsters reach ‘fighting age.’ At most, only 150,000 of them will manage to find lawful employment opportunities, i.e., in opium-free farming or with the army and police units[24]. The majority of insurgents come from this population group.

3.2.5.2 Spin Giri

These traditional leaders usually hold jurisdiction within tribal territory which tends to rarely coincide with modern state boundaries. Overall decision-making power (especially on important issues) that affects the tribe as a whole is taken by the overall heads of each tribe. Leadership among tribes tends to be inherited within an elite family. The most influential titles are passed down by birth to male children[25]. The leadership among traditional communities comes from what is called spin giri – the white bearded elders who either function in a high level role (e.g. khan, mir, beg, wakil) or more local decision makers at the village level (e.g. mirbak, Malik). All of them have a rather high form of legitimacy among Afghan society that should not be underestimated. In traditional decision-making bodies such as jirgas and shuras, only influential men of a certain age, family background and economic power (land holding is especially important), with negotiation skills and good linkages to the government, are included.

3.2.6 Beliefs

The study team extracted beliefs for all 13 demographic groups applicable to the issues of security, infrastructure, and governance. For instance, the ‘poor’ demographic possessed the belief that illegal

employment (such as performing insurgent tasks) was merited given the economic challenges within Helmand Province. The study team identified 14 distinct beliefs across the 13 demographic groups that aligned with the study issues of security, infrastructure, and governance. The beliefs aligned with study issues are listed in the table below.

Table 2: Beliefs that Define the Three Population Issue Stances.

Security									
Accepts US/ISAF intervention.	Actively supports the insurgency.	ANSF not a viable employment option.	Distrusts ISAF forces.	Helmand/ Afghanistan is not secure.	Outsiders not welcome.	Pakistan ties OK for commerce.	Supports Taliban and its ideology.	Supports Taliban reconciliation program.	Tolerates illicit commerce (opium trade).
Infrastructure									
Accepts US/ISAF intervention.	Actively supports the insurgency.	Distrusts ISAF forces.	Government should provide infrastructure.		Pakistan ties OK for commerce.	Tolerates illicit commerce (opium trade).		Willing to accept illegal / illicit job.	
Governance									
Accepts US/ISAF intervention.	Actively supports the insurgency.	Distrusts ISAF forces.	Government should provide infrastructure.	Recognizes government authority to enforce laws.		Supports Taliban and its ideology.	Supports Taliban reconciliation program.	Tolerates illicit commerce (opium trade).	Government is ineffective / irrelevant.

To support data development, the study team convened an Afghan SME workshop to elicit expert knowledge and opinions on security, infrastructure and governance in the Helmand Province. Participants completed a survey designed to capture their input on how a pre-conceived set of events would impact beliefs on security, infrastructure, and governance. Workshop results established starting conditions for beliefs and issue stances, and estimated the impact of future events on entity beliefs. The SMEs also confirmed the demographic dimensions and groups, beliefs, and other actor events as reasonable, providing valuable insight to the modeling effort.

The SME workshop also provided data on the relationship between an entity's success or failure of acquiring essential services and the impact of this event on their beliefs. Specifically, entities in the CG model possessed a behavior for each essential service in the model. Success or failure of acquiring an essential service affected three aspects of the entity: (1) its future decision-making regarding acquiring essential services, (2) its belief stances, and (3) its issue stances.

3.3 Scenarios

Scenarios in the CG model consisted of population entities (agents) performing the following actions:

- Consuming essential goods and services,
- Determining whether to seek essential services using the TPB,
- Interacting successfully (or not) with an essential server to acquire essential services,
- Reacting to success or failure to acquire essential services,
- Communicating successfully (or not) via the social network their success or failure to acquire essential services,

- Reacting to events by other actors, and
- Communicating successfully (or not) via the social network their reaction to an event.

Consumption of essential goods and services was a stochastic event tailored to individual entity stereotypes. The study team modeled 13 essential services tailored to the Helmand Province. Determining whether to seek essential services was a stochastic event resulting from the intention node likelihoods in the entity's TPB network. Four parameters in the infrastructure sub-model that impacted success or failure of acquiring essential services were server operating times, server capacity, server transfer rates, and extent of server damage. Reacting to success or failure of acquiring essential services was a deterministic event that results in implementation of case files that impacted the entity's TPB network and applicable beliefs. Communicating with fellow entities the success or failure of acquiring essential services depended on proximity to other entities and a stochastic process resulting from strength of social ties between population groups. Successful communication resulted in implementation of the same case files impacting the receiver in the same manner as the sender.

Reacting to events by other actors was a deterministic process resulting in implementation of case files that impact the entity's applicable beliefs. Communicating with fellow entities the reaction to the event followed the same communication process described above. Successful communication regarding reaction to events resulted in implementation of the same case files impacting the receiver in the same manner as the sender.

3.3.1 Actors

Scenario development also required the study team to identify other actors in Helmand that influence the population's stances on issues. Other actors are defined as individuals or groups that perform events that affect the population. The study team selected five actors of interest to represent in the model: ISAF, Taliban, Government of the Islamic Republic of Afghanistan (GIROA), NGOs, and Helmand women (to represent the role and influence of females in the population). The study team selected these actors for the following reasons:

- ISAF. Insights from the study may help inform COAs available to ISAF that support COIN and stability operations, making ISAF a logical actor. The ISAF actor executed lethal and non-lethal events in the scenarios, directly impacting the population and their beliefs.
- Taliban. The Taliban is the primary insurgent group in Helmand Province and the greatest obstacle to stability. Taliban operations also influence infrastructure and governance issues. The Taliban actor executed lethal and non-lethal events in the scenarios, to include recruiting and information operations.
- GIROA. Governance and the services provided by the government are one of three issues of interest for the study. Essential services and the supporting infrastructure for essential services is a critical function of government and society. Of particular frustration to the Helmand population is the absence of infrastructure services provided by GIROA. The GIROA actor provided essential services in the scenarios.
- NGOs. Currently, NGO presence in Helmand is limited, requiring analysis to determine whether increased NGO presence will improve stability operations. The NGO actor provided essential services in the scenarios.
- Women. The intent of modeling Helmand women was to determine female influence within the nuclear family, and particularly regarding their influence over a prominent population group – military age sons. Recognizing the potential influence women possess in support of stability operations, the U.S. Marine Corps has formed and activated Female Engagement Teams (FETs) that seek interaction with Afghan women to address their specific needs and collect information.

Women are generally more open to the heart-and-minds concept, to include improved education and an end to violence[26]. The women actors executed recruiting events in the scenarios for ISAF and Taliban.

3.3.2 Events

The table below lists actors and associated behaviors/events that were scripted in the CG model that impacted population stances on security, infrastructure, and governance.

Table 3: Actors and Behaviors to Events.

Actor	Behavior/Event
ISAF	Initiates "presence patrols" twice daily.
	Conducts a raid and takes some of your neighbors into custody.
	Cordons off your street and searches for suspects.
	Meets with your leaders and shuras.
	Eradicates opium from the fields.
Taliban	Sends threatening letters to your house at night.
	Plants an IED that explodes and kills your neighbors.
	Provides you and your neighbors food, water and clothes.
	Kills a community leader that you admire in your town.
	Convinces some of your neighbors to join their forces.
GIRoA	Provides you and your neighbors food and water and clothes.
NGO	Provides you and your neighbors food and water and clothes.
Women	Tells you she would be proud of you if you joined the Taliban.
	Tells you she would be proud of you if you joined ANSF forces.

The study team defined the baseline scenario as all 14 events listed above modeled at a frequency representing the pace of present-day events in Helmand Province. For instance, SMEs report that GIRoA representatives provide essential services to Helmand approximately once per month. Consequently, the study team modeled GIRoA providing essential services once per month in the baseline scenario. A noted limitation to scheduling events in this manner is that actors do not adapt to existing conditions. For instance, the dynamic decision-making process related to force allocation based on perceived conditions was not considered for this study.

3.3.3 Alternatives

To help focus exploration of viable COAs in support of COIN and stability operations, the study sponsor provided several notional scenarios that align with the issues of security, infrastructure, and governance. The study team modeled six of the sponsor's excursions using variations of the baseline scenario, referred to as alternative scenarios. Alternative scenarios consisted of the 14 baseline events modeled at frequencies tailored to the notional scenarios and the experimental design. The six alternative scenarios are described below:

- Alternative A. Increased frequency of services provided by NGOs to simulate heightened NGO presence in place of ISAF,

- Alternative B. Increased frequency of services provided by GIRoA to simulate improved government capacity,
- Alternative C. Increased frequency of services provided by NGOs and GIRoA to simulate increased social services,
- Alternative D. Increased frequency of ISAF raids, cordons, and meetings with leaders (e.g., key leader engagements (KLEs)) to simulate a combined kinetic and communication campaign,
- Alternative E. Increased frequency of ISAF presence patrols to simulate providing the population security rather than kinetic action against the insurgency, and
- Alternative F. Increased frequency of ISAF presence patrols and meetings with leaders (e.g., KLEs) to simulate increased population security and communications campaign.

3.3.4 Design of Experiment

The study team implemented a fractional factorial DOE to explore significant factors impacting the population's issue stances impacted by typical events occurring in Helmand Province. The DOE is the mechanism used to vary the settings of these factors of interest to explore the simulation model results and to assess how selected input factors affect the response surface or MOEs across the range of scenarios. The DOE was constructed in a matrix where every column corresponded to a factor, and the entries within the column are settings or factor levels for this factor. Each row represented a particular combination of factor levels that defined a scenario or design point. The use of the CG model combined with the DOE allowed for exploration of landscapes of COAs.

The study team identified two types of experimental factors: decision factors and noise factors. Decision factors, also known as controllable factors, are factors that represent controllable actions available to decision makers for real world problems. Noise factors, also known as uncontrollable factors, are factors not easily controlled or controlled at great expense in the real world setting.

The study team selected 16 total experimental factors based on discussions with SMEs and calibration experiments designed to scope factors. The behaviors/events listed in Table 3 performed by ISAF, GIRoA, and NGOs defined the decision factors. These factors potentially influence the population's stance on the three issues under study. The behaviors/events listed in Table 3 performed by Taliban and women were noise factors.

The study team applied a 2^{17-12} fraction factorial design of the 16 aforementioned experimental factors. The design consisted of 32 design points (or variations of the baseline scenario) with a maximum pair wise correlation of 0.0352.

The system modeled was a terminating simulation meaning that the scenario in this research started at a defined state and ended when they reach some other defined event. Accordingly, the initial state of the model at the beginning of the simulation is that all of the beliefs, behaviors, and issue stance are at a specific state based on SME input. Entities consume and seek services according to their TPB until events begin to be executed by other actors. There are a fixed number of events for each variations of the scenario (e.g., alternative scenarios, design point) defined by the behavior/events level setting (i.e. high frequency, low frequency). The system terminates when all of the behaviors/events are completed. Since this research experiments with terminating simulation models, each experiment comprises multiple replications per variation of the scenario (each replication is treated as a sample) over a period of interest (i.e. 180 simulation days) defined by the terminating condition using a different random seed for each experiment. This procedure enables statistically independent and unbiased observations to be on the response variables of interest in the system over the time period simulated.

The study team executed the baseline scenario (defined as all factors set to low levels) consisting of 32 design points. SMEs reviewed the initial output and deemed the results reasonable. Additionally, the study team conducted a preliminary data analysis of these results to gain initial insights on significant (and insignificant) design factors.

After review by SMEs, the study team conducted model and scenario calibration. Model calibration included adjusting case files to reflect SME workshop input and creating Bayesian networks for issues from Gallup poll data. Scenario calibration included development of alternative scenarios by adjusting factor levels accordingly to represent the sponsor's notional scenario goals.

The study team re-executed scenarios following calibration, to include alternative scenarios. The study team conducted 30 replications of all scenarios. Execution time for all scenarios ranged from 10-20 minutes.

4.0 ANALYSIS RESULTS

4.1 Overall Results

Primary MOE for this analysis included population stances on security, infrastructure, and governance in Helmand Province. Inputs affecting these measures include events from other actors (introduced through experimental design factors in the scenarios), interaction with the CG model's infrastructure sub-model, and communication across a social network. Findings presented below and shown in Table 4 are based on trends in the output and magnitude of results relative to other scenarios, and should not be interpreted as predictive.

Table 4: Overall Results for the Three Issue Stances and Alternatives.

Issue Stance	ALT A	ALT B	ALT C	ALT D	ALT E	ALT F
Security	0.7%	1.0%	1.4%	-0.1%	2.9%	3.1%
Infrastructure	0.3%	0.5%	0.8%	-0.2%	1.7%	1.8%
Governance	0.3%	0.7%	0.8%	0.1%	1.5%	1.7%

Insights from the overall results show that the Helmand population is diverse across socio-cultural dimensions, leading to varying reactions to the events in the alternative scenarios. Notably, increased frequency of ISAF presence patrols (ALT E and ALT F) had the most positive effect (from an ISAF perspective) on the perception of security, infrastructure, and governance when compared to the baseline scenario. Additionally, an increase in the frequency of either NGO services (ALT A) or GIRoA services (ALT B) resulted in a more positive perception of security, infrastructure, and governance but was most noticeable when both NGO and GIRoA services were increased (ALT C). Conversely, increased ISAF kinetic events, such as raids and cordon and searches (ALT D), had a slightly negative impact on the perception of security and infrastructure. Details of findings by issue are presented below.

4.2 Security

The population's stance on security improved (from an ISAF perspective) as ISAF non-kinetic operations increased, namely through presence patrols and Key Leader Engagements (KLEs). The increase of Taliban non-kinetic operations, such as providing services and recruitment, negatively impacted the population's security stance. The most significant factor impacting the population's perception of security was ISAF presence patrols.

Table 5: Most Significant Factors Affecting Security.

Actor	Event	Significance	Impact on Security Stance
ISAF	Presence Patrols (non-kinetic)	High	Positive
ISAF	Key Leader Engagements (non-kinetic)	Medium	Positive
Taliban	Provides Services (non-kinetic)	Medium	Negative
Taliban	Recruit (non-kinetic)	Medium	Negative

Analyzing the results by alternative scenario provided notable findings. Specifically, ISAF presence patrols and KLEs had the greatest impact on the population's security stance when analyzing results by scenario. Readily apparent in both trend and magnitude, presence patrols and KLEs played significant roles impacting the population's security stance. With the exception of alternative scenario, all scenarios produced a positive trend in security stance as compared to the base case scenario. The relative magnitude of security stances generated from alternative scenarios E and F were consistently higher than results from other scenarios. The study team modeled alternative scenario E with ISAF presence patrol events at the high frequency, and alternative scenario F with ISAF presence patrol events and KLEs at the high frequency. No other alternative scenarios included presence patrols or KLEs at a high frequency. This result supports the finding that ISAF presence patrols and KLEs played a significant (positive) role regarding the population's stance on security.

Alternative scenarios A, B, and C also produced positive trends in security stance as compared to the base case scenario, but with less magnitude than alternative scenarios D and E. The study team modeled alternative scenario A with NGOs providing services at the high frequency, alternative scenario B with GIROA providing services at the high frequency, and alternative scenario C with both NGOs and GIROA providing services at the high frequency. No other alternative scenarios included NGO and GIROA providing services at a high frequency. This result supports the finding that GIROA providing services played a significant (positive) role regarding the population's stance on security. Conversely, ISAF kinetic events, such as raids, had a negative impact on the population's stance on security. Specifically, alternative scenario D showed a negative trend in security stance as compared to the base case scenario. The study team modeled alternative D with ISAF raids at a high frequency. No other alternative scenarios included ISAF raids at a high frequency.

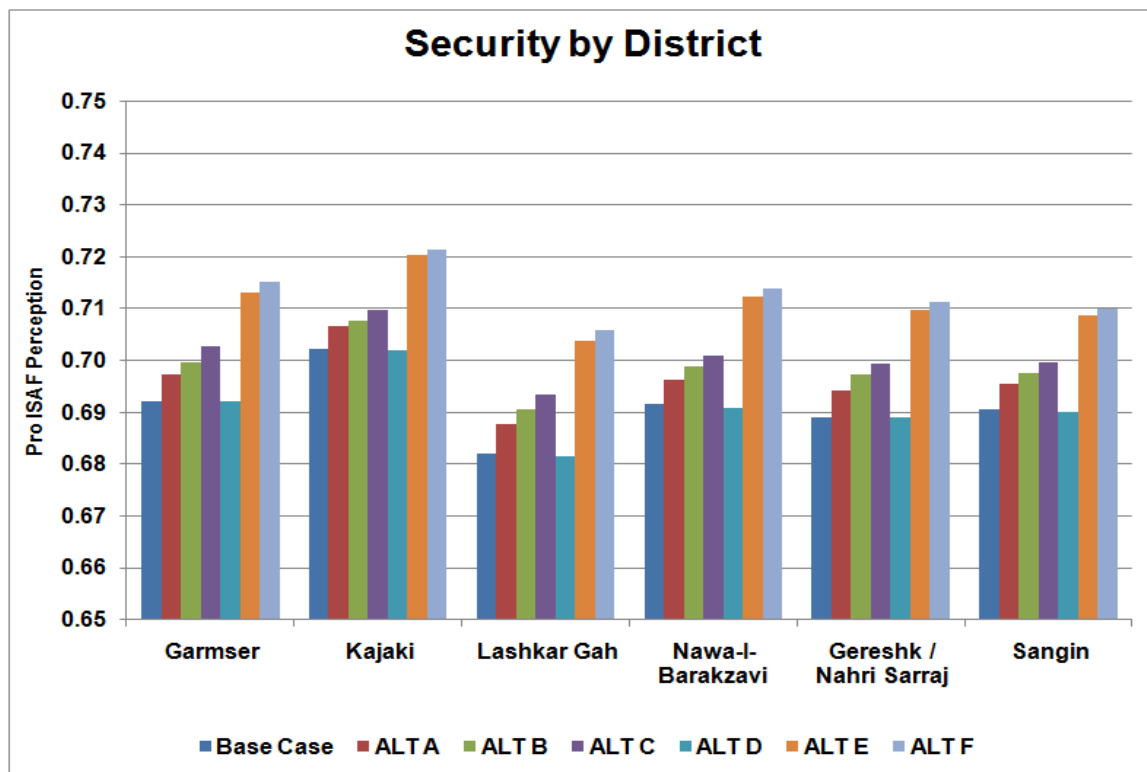


Figure 3: Security Results for each District.

Assessing security stances by district revealed that Lashkar Gah consistently generated the least positive security stance across all alternative scenarios as shown in Figure 3. Political and tribal affiliations, namely political fundamentalists and marginalized/ violent tribes, influenced these results in Lashkar Gah. Marginalized/ violent tribes resided in Lashkar Gah in greater numbers than all other districts. Political fundamentalists resided in Lashkar Gah in greater numbers than all other districts, with the exception of Gereshk. Fundamentalists and marginalized/ violent groups were adversely affected by events in the scenarios, many of which clashed with their traditions and customs. These groups generally distrust ISAF forces and do not welcome or accept outsiders.

Regression and CART analysis showed that the population's stance on security was negatively impacted following insurgent non-kinetic operations, such as providing services and recruiting. The contour plot in Figure 4 shows security stances plotted against the number of ISAF presence patrols per month and the number of Taliban service events provided per month. The contour regions inside the plot (filled in different colors) correspond to different ranges of mean security stance. The plot is read by selecting an intersection between ISAF presence patrols (x-axis) and Taliban provide services (y-axis), and then examining the corresponding mean security stance. This plot complements the metamodel and interaction plot results from Appendix F. For instance, ISAF presence patrols modeled at a high level (112 patrols per month for the six districts) resulted in a positive perception of security (blue area). Conversely, Taliban provides services modeled at a high level (eight occurrences per week for the six districts) and ISAF presence patrols modeled at a low level resulted in a negative perception of security (red area).

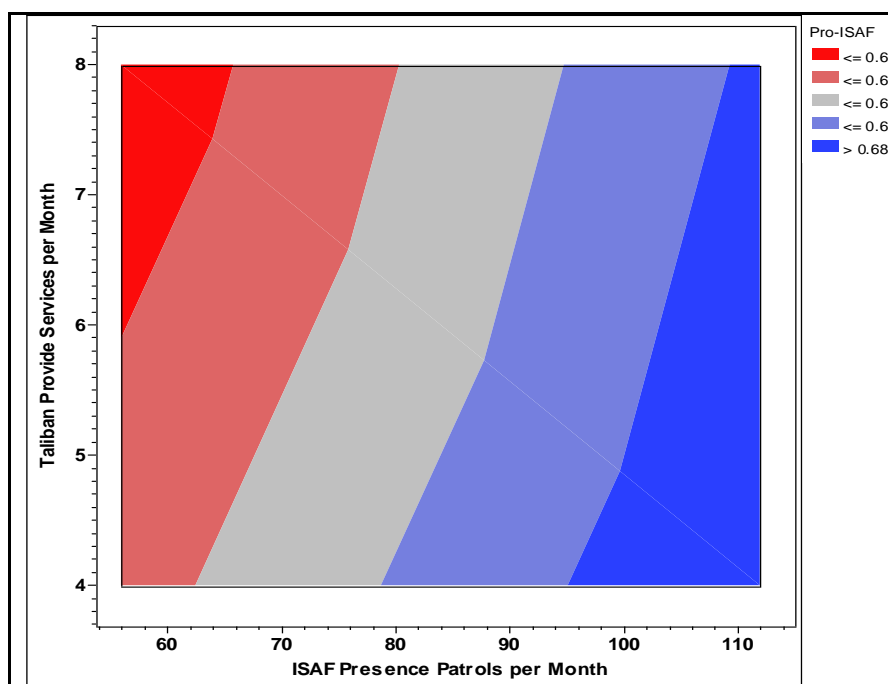


Figure 4: Contour Plot of ISAF Presence Patrols vs. Taliban Providing Services.

Other notable factors impacting the population's stance on security at a low level of significance were ISAF opium eradication, and Taliban kinetic operations. These factors impacted the population's security stance, but to a lesser degree than the other factors. The study team assessed the trend for ISAF opium eradication operations and Taliban kinetic operations (such as IED attacks or killing a community leader) as negatively impacting the stance on security.

4.3 Infrastructure and Essential Services

The population's stance on infrastructure improved (from an ISAF perspective) as ISAF non-kinetic operations increased, namely through presence patrols. The increase of Taliban non-kinetic operations, namely provide services and night letters, negatively impacted the population's infrastructure stance. The most significant factor impacting the population's perception of infrastructure was ISAF presence patrols, see Table 6.

Table 6: Most Significant Factors Affecting Infrastructure.

Actor	Event	Significance	Impact on Infrastructure Stance
ISAF	Presence Patrols (non-kinetic)	High	Positive
Taliban	Night Letters (non-kinetic)	Medium	Negative
Taliban	Provides Services (non-kinetic)	Medium	Negative

Analyzing the results by alternative scenario provided notable findings. Specifically, ISAF presence patrols and KLEs had the greatest impact on the population's infrastructure stance when analyzing results by scenario. Assessing trends and magnitude of infrastructure stances, presence patrols and KLEs played significant roles impacting the population's perception of infrastructure. These trends and relative magnitudes can be observed in Figure 5.

The bar chart in Figure 5 shows infrastructure stances consolidated by district for each alternative scenario. With the exception of alternative scenario D, all scenarios produced a positive trend in infrastructure stance as compared to the base case scenario. The relative magnitude of infrastructure stances generated from alternative scenarios E and F were consistently higher than results from other scenarios. The study team modeled alternative scenario E with ISAF presence patrol events at the high frequency, and alternative scenario F with ISAF presence patrol events and KLEs at the high frequency.

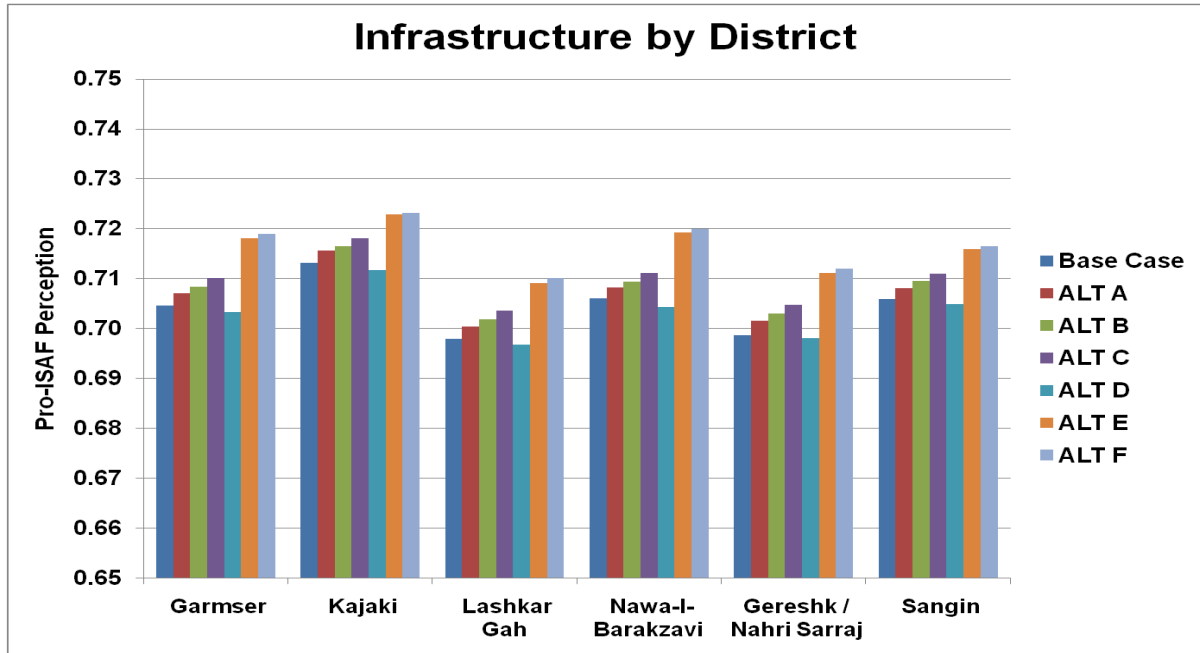


Figure 5: Infrastructure Results for each District.

No other alternative scenarios included presence patrols or KLEs at a high frequency. This result supports the finding that ISAF presence patrols played a significant (positive) role regarding the population's stance on infrastructure, and to a slightly lesser degree KLEs played a significant role.

Alternative scenarios A, B, and C also produced positive trends in security stance as compared to the base case scenario, but with less magnitude than alternative scenarios D and E. The study team modeled alternative scenario A with NGOs providing services at the high frequency, alternative scenario B with GIRoA providing services at the high frequency, and alternative scenario C with both NGOs and GIRoA providing services at the high frequency. No other alternative scenarios included NGO and GIRoA providing services at a high frequency. This result supports the finding that GIRoA providing services played a significant (positive) role regarding the population's stance on security.

Assessing infrastructure stances by district revealed that Lashkar Gah and Gereshk consistently generated the least positive infrastructure stance across all alternative scenarios as shown in Figure 8. Family status, namely the unemployed/poor, influenced these results in Lashkar Gah and Gereshk. High densities of unemployed/poor resided in Lashkar Gah and Gereshk. The unemployed/poor generally believe that the government should provide infrastructure, are more tolerant of illicit commerce, and may be more willing to accept illegal/illicit jobs. These beliefs contributed to low infrastructure perceptions.

Regression and CART analysis showed that the population's stance on infrastructure was negatively impacted following specific ISAF non-kinetic operations, namely opium eradication. The contour plots in Figure 6 show infrastructure stances plotted against the number of ISAF presence patrols per month and

the number of ISAF opium eradication operations. The plots illustrate that the frequency of ISAF presence patrols has an impact on how the population reacts to opium eradication. Positive perceptions of infrastructure (blue area) occurred as ISAF presence patrols increased and ISAF opium eradication operations decreased. Negative infrastructure perceptions are more pronounced for unemployed/poor than the inherited and achieved family status dimension.

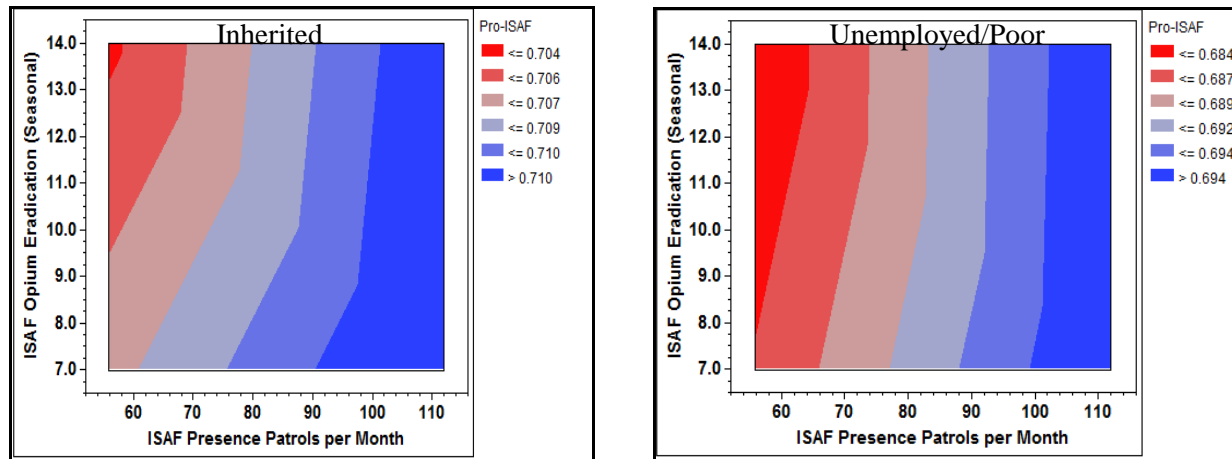


Figure 6: Contour Plots of ISAF Presence Patrols vs. Opium Eradication for the Family Status Dimension.

Other notable factors impacting the population's stance on infrastructure at a medium level of significance were Taliban night letters and Taliban providing services. The study team assessed the trend for Taliban night letters and Taliban providing services as negative regarding infrastructure stance. Additionally, the study team assessed Taliban kinetic operations and Taliban recruitment as notable. These factors impacted the population's stance on infrastructure, but to a lesser degree than factors listed in Table 6. The study team assessed the trend for Taliban kinetic operations (such as IED attacks or killing a community leader) and Taliban recruitment as negative regarding infrastructure perspective.

4.4 Governance

The population's stance on governance improved (from an ISAF perspective) as ISAF non-kinetic operations increased, namely through presence patrols and KLEs. The increase of Taliban non-kinetic operations, namely provide services, negatively impacted the population's governance stance. The most significant factor impacting the population's perception of governance was ISAF presence patrols.

Table 7: Most Significant Factors Affecting Infrastructure.

Actor	Event	Significance	Impact on Governance Stance
ISAF	Presence Patrols (non-kinetic)	High	Positive
ISAF	Key Leader Engagements (non-kinetic)	Medium	Positive
Taliban	Provides Services (non-kinetic)	Medium	Negative

Analyzing the results by alternative scenario provided notable findings. Specifically, ISAF presence patrols and KLEs had the greatest impact on the population's governance stance when analyzing results by

scenario. Assessing trends and magnitude of governance stances, presence patrols and KLEs played significant roles impacting the population's perception of governance. These trends and relative magnitudes can be observed in Figure 7.

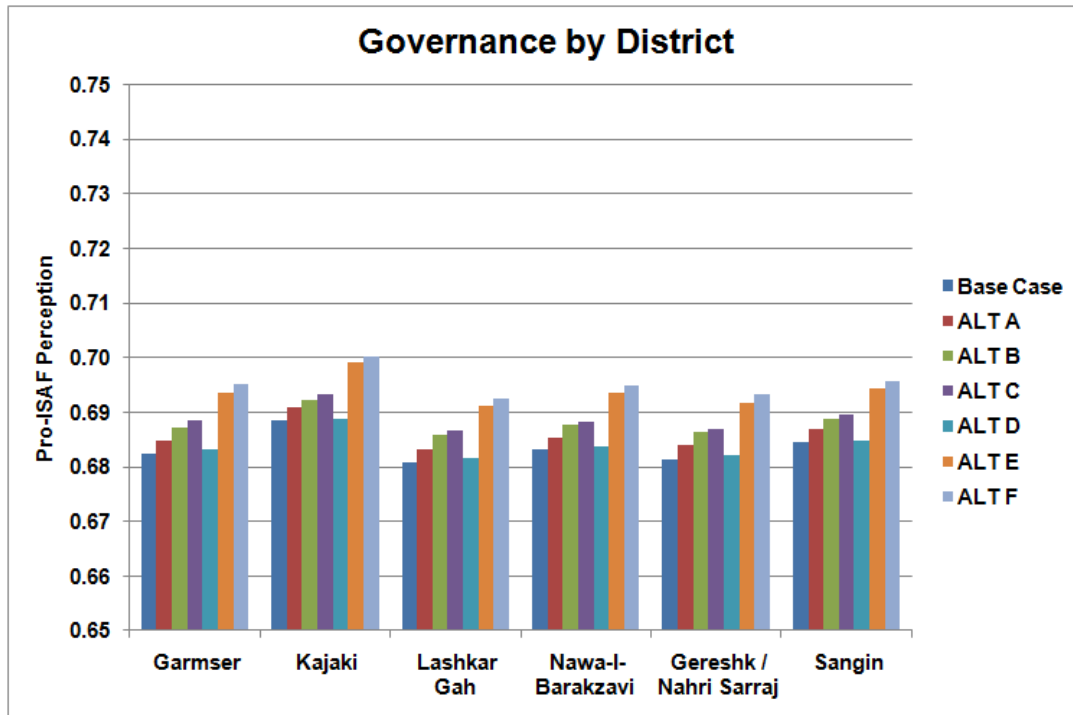


Figure 7: Governance Results for each District.

The bar chart in Figure 7 shows governance stances consolidated by district for each alternative scenario. All scenarios produced a positive trend in governance stance as compared to the base case scenario. The relative magnitude of governance stances generated from alternative scenarios E and F were consistently higher than results from other scenarios. The study team modeled alternative scenario E with ISAF presence patrol events at the high frequency, and alternative scenario F with ISAF presence patrol events and KLEs at the high frequency. No other alternative scenarios included presence patrols or KLEs at a high frequency. This result supports the finding that ISAF presence patrols and KLEs played a significant (positive) role regarding the population's stance on governance.

Alternative scenarios A, B, and C also produced positive trends in governance stance as compared to the base case scenario, but with less magnitude than alternative scenarios D and E. The study team modeled alternative scenario A with NGOs providing services at the high frequency per Table 11, alternative scenario B with GIRoA providing services at the high frequency, and alternative scenario C with both NGOs and GIRoA providing services at the high frequency. No other alternative scenarios included NGO and GIRoA providing services at a high frequency. This result supports the finding that GIRoA providing services played a significant (positive) role regarding the population's stance on governance.

Assessing governance stances by district revealed that Kajaki consistently generated the most positive governance stance across all alternative scenarios, while Lashkar Gah, Nawa, and Gereshk generally produced the least positive governance stance as shown in Figure 7. Political and tribal affiliations influenced these results. Pro-government tribes resided only in Kajaki and Sangin. Pro-government tribes had the highest perception of governance and recognized government authority. These beliefs contributed to high governance perceptions.

Political fundamentalists and marginalized/ violent tribes resided predominantly in Lashkar Gah, Nawa, and Gereshk. Fundamentalists and marginalized/violent groups had the lowest perception of governance, generally distrusted ISAF forces, and believed that the government was ineffective or irrelevant. These beliefs contributed to low governance perceptions.

Regression and CART analysis showed that the population's stance on governance was negatively impacted following specific ISAF non-kinetic operations, namely opium eradication. The contour plot in Figure 8 shows governance stances plotted against GIRoA provide services events and the number of ISAF opium eradication operations. The plot shows that governance perception decreased as ISAF efforts to eradicate opium increased. The plot also illustrates that GIRoA providing services partially mitigates the negative impact of opium eradication.

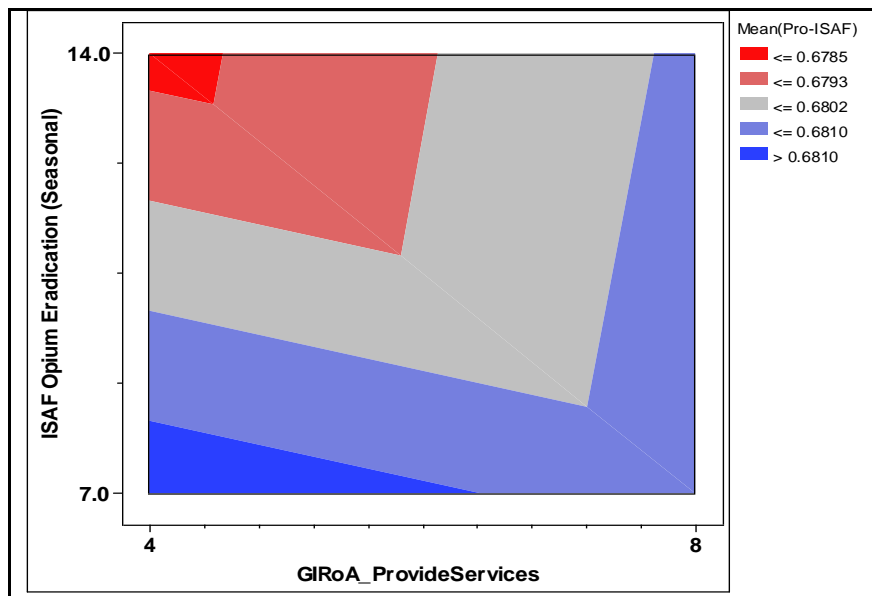


Figure 8: Contour Plot of GIRoA Services vs. Opium Eradication.

Another notable factor impacting the population's stance on governance at a medium level of significance was Taliban providing services. The study team assessed the trend for Taliban providing services as negative regarding governance stance. Additionally, the study team assessed Taliban kinetic operations, Taliban night letters, Taliban recruitment, and women communicating to join ANSF as notable. These factors impacted the population's stance on governance, but to a lesser degree than the other factors. The study team assessed the trend for Taliban kinetic operations (namely killing a community leader), Taliban night letters, and Taliban recruitment as negative regarding governance perception. Conversely, women communicating to join ANSF generated a positive trend in governance perspective.

5.0 SUMMARY

The following is a summary of findings to support COA development in Helmand Province. General findings include modeling the affects of various scenarios on the population in Helmand provides a means to evaluate courses of action. The multi-faceted approach that the team used showed that the district, political affiliation, and family status had the greatest impact on the population perception results.

The specific results based on analysis of the scenarios by district and population group revealed that the most significant positive impact on the population's perception of security, infrastructure, and governance

was directly related to the amount of non-kinetic operations. Conversely, scenarios that involved an increase in kinetic operations initiated by either side negatively impacted the security stance for all population groups.

Further, for scenarios that involved humanitarian assistance we were able to discern slight differences in the population's perceptions. For instance, when GIRoA or NGOs provided services, this generally improved the perception of governance in comparison to when ISAF provided these services unilaterally. Additionally, when GIRoA or NGOs provided services, this positively impacted the population's perception of infrastructure.

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